

1 CLAIMS:

2 1. A deposition method comprising:

3 at a first temperature, contacting a substrate with a surface  
4 activation agent and adsorbing a first layer over the substrate; and

5 at a second temperature greater than the first temperature,  
6 contacting the first layer with a first precursor and chemisorbing a  
7 second layer at least one monolayer thick over the substrate.

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9 2. The deposition method of claim 1 wherein the first layer  
10 enhances a chemisorption rate of the first precursor compared to the  
11 substrate without the surface activation agent adsorbed thereon.

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13 3. The deposition method of claim 1 wherein the surface  
14 activation agent comprises a metal halide, metal organic, alcohol,  
15 carboxylic acid, or amine.

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17 4. The deposition method of claim 1 wherein the surface  
18 activation agent comprises at least one of  $\text{TiCl}_4$ ,  $\text{WF}_6$ ,  
19 hexamethyldisilazane, tetrakis(dimethylamido)titanium,  
20 tetraethylorthosilicate,  $\text{H}_2\text{O}$ , methanol, ethanol, isopropanol, formic acid,  
21 acetic acid, oxalic acid,  $\text{NH}_3$ , methylamine, ethylamine, or dimethylamine.

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1 5. The deposition method of claim 1 wherein the first  
2 temperature is less than a chemisorption temperature of the surface  
3 activation agent on the substrate.

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5 6. The deposition method of claim 1 wherein the first and  
6 second temperatures are those of at least a portion of the substrate.

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8 7. The deposition method of claim 1 wherein the first and  
9 second temperatures are those of an outermost surface of the substrate.

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11 8. The deposition method of claim 1 wherein the first and  
12 second temperatures are respectively those of the surface activation agent  
13 and first precursor.

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15 9. The deposition method of claim 1 wherein the substrate  
16 comprises a bulk semiconductor wafer.

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18 10. The deposition method of claim 1 wherein the second layer  
19 is chemisorbed on the first layer.  
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11. The deposition method of claim 1 wherein the contacting the substrate comprises contacting a previously chemisorbed layer of a deposition precursor and adsorbing the surface activation agent on the previously chemisorbed layer.

12. The deposition method of claim 1 further comprising substantially displacing the first layer from over the substrate during the chemisorbing the second layer.

13. The deposition method of claim 1 wherein the surface activation agent is the same as the first precursor.

14. The deposition method of claim 1 wherein the second layer consists essentially of a monolayer.

15. The deposition method of claim 1 wherein the first precursor consists essentially of a single precursor species.

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1           16. The deposition method of claim 1 further comprising  
2 contacting the second layer with a second precursor and chemisorbing a  
3 third layer at least one monolayer thick on the second layer, forming a  
4 chemisorption product of the first and second precursors comprising a  
5 deposition material.

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7           17. The deposition method of claim 16 wherein the chemisorption  
8 product consists essentially of a monolayer of the deposition material.

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18. A deposition method comprising:

at an initial temperature less than a chemisorption temperature of  
a surface activation agent, adsorbing the agent over a substrate; and

at a deposition temperature greater than the initial temperature,  
atomic layer depositing a first species over the substrate.

19. The deposition method of claim 18 wherein the surface  
activation agent enhances an atomic layer deposition rate of the first  
species compared to the substrate without the surface activation agent  
adsorbed thereon.

20. The deposition method of claim 18 wherein the surface  
activation agent comprises a metal halide, metal organic, alcohol,  
carboxylic acid, or amine.

21. The deposition method of claim 18 wherein the surface  
activation agent comprises at least one of  $\text{TiCl}_4$ ,  $\text{WF}_6$ ,  
hexamethyldisilazane, tetrakis(dimethylamido)titanium,  
tetraethylorthosilicate,  $\text{H}_2\text{O}$ , methanol, ethanol, isopropanol, formic acid,  
acetic acid, oxalic acid,  $\text{NH}_3$ , methylamine, ethylamine, or dimethylamine.

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1           22. The deposition method of claim 18 wherein the surface  
2 activation agent is the same as the first species.

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4           23. The deposition method of claim 18 wherein the initial and  
5 deposition temperatures are those of at least a portion of the substrate.

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7           24. The deposition method of claim 18 further comprising  
8 substantially displacing the surface activation agent from over the  
9 substrate during the atomic layer depositing the first species.

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11           25. The deposition method of claim 18 further comprising atomic  
12 layer depositing a second species on the atomic layer deposited first  
13 species, the deposited first and second species combined comprising a  
14 deposition material.

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26. A deposition method comprising:

adsorbing a surface activation agent over a substrate, at least an outer surface of the substrate being at a first temperature less than a chemisorption temperature of the agent;

altering a temperature of at least a portion of the substrate;

chemisorbing a monolayer of a first compound over the substrate, at least an outer surface of the substrate being at a second temperature greater than the first temperature, and substantially displacing the agent from over the substrate; and

chemisorbing a monolayer of a second compound on the first compound monolayer.

27. The deposition method of claim 26 wherein the adsorbed surface activation agent enhances a chemisorption rate of the first compound compared to the substrate without the surface activation agent adsorbed thereon.

28. The deposition method of claim 26 wherein the surface activation agent comprises a metal halide, metal organic, alcohol, carboxylic acid, or amine.

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1 29. The deposition method of claim 26 wherein the surface  
2 activation agent comprises at least one of  $\text{TiCl}_4$ ,  $\text{WF}_6$ ,  
3 hexamethyldisilazane, tetrakis(dimethylamido)titanium,  
4 tetraethylorthosilicate,  $\text{H}_2\text{O}$ , methanol, ethanol, isopropanol, formic acid,  
5 acetic acid, oxalic acid,  $\text{NH}_3$ , methylamine, ethylamine, or dimethylamine.

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7 30. The deposition method of claim 26 wherein the surface  
8 activation agent is the same as the first compound.



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31. A deposition method comprising:

contacting a bulk semiconductor wafer with a cooling medium to establish at least an outer surface of the wafer at an initial temperature;

contacting the wafer with a surface activation agent and adsorbing a first layer on the wafer, the initial temperature being less than a chemisorption temperature of the agent;

placing the wafer on a heated wafer chuck and establishing at least the outer surface of the wafer at a deposition temperature greater than the initial temperature; and

contacting the first layer with a deposition precursor and chemisorbing a second layer at least one monolayer thick over the wafer.

32. The deposition method of claim 31 wherein the contacting with the cooling medium comprises elevating the wafer over the heated wafer chuck and contacting the wafer with cooling gases and wherein the placing the wafer comprises lowering the wafer onto the heated wafer chuck.

33. The deposition method of claim 31 wherein the contacting with the cooling medium comprises placing the wafer on a cooled wafer chuck different from the heated wafer chuck.

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34. The deposition method of claim 31 wherein the contacting with the surface activation agent and deposition precursor comprises moving the wafer within a single chamber of a deposition apparatus from a first zone containing the surface activation agent to a second zone containing the deposition precursor.

35. The deposition method of claim 34 wherein the moving is accomplished by linear translational motion of the heated wafer chuck.

36. The deposition method of claim 31 wherein the contacting with the surface activation agent and deposition precursor comprises moving the wafer from a cooled wafer chuck in a first chamber of a multiple chamber deposition apparatus to a second chamber of the apparatus wherein contacting with the agent and contacting with the precursor may occur.

37. The deposition method of claim 36 wherein the moving is accomplished by a robotic wafer handler.

38. The deposition method of claim 31 wherein the first layer enhances a chemisorption rate of the deposition precursor compared to the wafer without the surface activation agent adsorbed thereon.

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39. The deposition method of claim 31 wherein the surface activation agent comprises a metal halide, metal organic, alcohol, carboxylic acid, or amine.

40. The deposition method of claim 31 wherein the surface activation agent comprises at least one of  $\text{TiCl}_4$ ,  $\text{WF}_6$ , hexamethyldisilazane, tetrakis(dimethylamido)titanium, tetraethylorthosilicate,  $\text{H}_2\text{O}$ , methanol, ethanol, isopropanol, formic acid, acetic acid, oxalic acid,  $\text{NH}_3$ , methylamine, ethylamine, or dimethylamine.

41. The deposition method of claim 31 wherein the surface activation agent is the same as the deposition precursor.

42. The deposition method of claim 31 wherein the second layer consists essentially of a monolayer.

43. The deposition method of claim 31 wherein the deposition precursor consists essentially of a single precursor species.

1 44. A deposition apparatus comprising:

2 a deposition chamber having at least one precursor gas dispenser  
3 in each of at least one contacting zone and at least one cooling gas  
4 dispenser in each of at least one cooling zone; and

5 a substrate chuck that moves by linear translational motion from  
6 the at least one contacting zone to the at least one cooling zone, the  
7 substrate chuck comprising a substrate lift that positions a deposition  
8 substrate at an elevation above a heated surface of the substrate chuck  
9 when dispensing a cooling gas in the at least one cooling zone and when  
10 dispensing a surface activation agent in the at least one contacting zone.  
11

12 45. The apparatus of claim 44 wherein the substrate comprises  
13 a bulk semiconductor wafer.  
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15 46. The apparatus of claim 44 wherein the deposition chamber  
16 has two contacting zones and one cooling zone and the substrate chuck  
17 moves from one contacting zone through the cooling zone to another  
18 contacting zone.  
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20 47. The apparatus of claim 46 wherein the cooling zone consists  
21 essentially of an inert gas curtain isolating the two contacting zones.  
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1 48. The apparatus of claim 44 wherein the substrate lift lowers  
2 a deposition substrate from the elevation above the heated surface of the  
3 substrate chuck when dispensing precursor gas in the at least one  
4 contacting zone.

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6 49. The apparatus of claim 44 wherein substrate lift comprises  
7 positioning pins of the substrate chuck.

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9 50. The apparatus of claim 44 wherein contacting and cooling  
10 zones are established with at least one of an inert gas curtain or  
11 suitable gas flow conditions.  
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1 51. A deposition apparatus comprising:  
2 at least one cooling chamber having a cooled substrate chuck;  
3 at least one contacting chamber having at least one precursor gas  
4 dispenser and having a heated substrate chuck including a substrate lift  
5 that positions a deposition substrate at an elevation above a heated  
6 surface of the heated substrate chuck when dispensing a surface  
7 activation agent in the contacting chamber; and  
8 a robotic substrate handler that moves a substrate from the at  
9 least one cooled substrate chuck to the at least one heated substrate  
10 chuck.

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12 52. The apparatus of claim 51 wherein the substrate comprises  
13 a bulk semiconductor wafer.

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15 53. The apparatus of claim 51 wherein the substrate lift lowers  
16 a deposition substrate from the elevation above the heated surface of the  
17 substrate chuck when dispensing precursor gas in the at least one  
18 contacting chamber.

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20 54. The apparatus of claim 51 wherein the substrate lift  
21 comprises positioning pins of the heated substrate chuck.  
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